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Integration of Marine Mammal Movement and Behavior into the Effects of Sound on the Marine Environment

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LONG-TERM GOALS

Integration of the Marine Mammal Movement and Behavior (3MB) model into the Effects of Sound on the Marine Environment (ESME) program contributes to the ultimate goal of creating an environmental impact assessment tool for Navy acoustic activities in the ocean.

OBJECTIVES

The objectives of the effort are to 1) integrate the 3MB module into the second generation model of ESME, 2) incorporate the influence of bathymetric features on simulated marine mammal (animat) movement, 3) develop more species models so that a library of species behavior is readily available for use, and 4) develop a standardized reporting method for the model that provides relevant information to users in the environmental community.

APPROACH

The proposed effort consists of four tasks, some of which will be completed in collaboration with Drs. Michael Porter and Martin Siderius of Heat, Light and Sound Inc. (HLS Inc.) and Dr. David Mountain of Boston University (BU). Task I involves integrating the current 3MB module with acoustic propagation models by development of application programming interfaces (API). Individual modules will likely consist of MS-DLLs and the initial targeted platform will be Windows-based PCs. Dr. Mountain will lead the API development and coordinate efforts on developing efficient data exchange between acoustic and mammal simulation modules.

Task II consists of implementing the ability for animats to interact with the simulated environment, thus more closely approximating biologically relevant behaviors of the simulated species. The candidate model will consist of combinatorial vector operations that determine the relative attraction of environmental features. For the course of the simulation, environmental factors will be assumed to be static.

Task III consists of developing several marine mammal species definitions as a library to be delivered with the ESME model. The species definitions will provide the end-user with a number of pre-defined species with which simulations may be run as well as reference models from which end-users may learn to create their own species definitions. Species model development will be dependent on the availability of dive and movement behavior of marine mammals.

Task IV involves development of a standard reporting format for results of acoustic exposure simulations. The reports will provide information to individuals involved in estimating impacts of anthropogenic acoustic activities as dictated by NEPA, the MMPA and the ESA. Specifically, take categories (as defined in the MMPA) will be used to categorically assign marine mammals to a level of impact (i.e. Level A (injury) or Level B (behavioral)). Thresholds for impact will be dictated by the user in accordance with the approved impact criteria for the action. Thresholds will be user-definable via the GUI prior to the run of the simulation. In addition, reports will keep track of acoustic exposure (acoustic or instantaneous) as well as movement patterns prior to and following exposure. The collective information will be useful in post-hoc analysis of the simulated event.

WORK COMPLETED

Funding for the program was received in the middle of May, 2007; work has only been conducted over the last four months. The major effort through this work period was the restructuring of the GUI into a modular, panel interface. Controls were simplified and performance improved by replacing tabbed and general behavior layouts with buttons that bring up a specific behavior panel displays. Access to all relevant modeling information, including environmental attractors, are now handled through a single panel interface. Additional programming capabilities include the ability to build vector models within the GUI, as opposed to importing text files, implementation of a behavior copy function to facilitate the creation of new behaviors, and the incorporation of “shore-following” behavior which prevents animals from being trapped against land masses if engaged in directed movement.

RESULTS

Restructuring the GUI for incorporation in a more widely usable format (i.e., not in MatLab) uncovered a number of bugs in the original 3MB code. The most significant of these was the potential for animals to get trapped against land masses if engaged in highly directed motion (e.g. migrating mammals). As a result, a number of code improvements were instituted, the most significant of which was the “shore following” behavior, to ensure that animals do not become trapped. The finding of the bug permitted overall improvement in code operation by carryover of various fixes to other aspects of the movement model.

IMPACT/APPLICATIONS

The integration of the ESME program with the capability to emulate the dive and movement behavior of marine mammals provides a significant advantage to modeling environmental impact than do current approaches used in Navy environmental assessments (EA) and impact statements (EIS). Specifically, current approaches assume static animats that receive the highest exposure level encountered in the water column at their location, regardless of the depth of the animat at the time of the exposure. This conservative approach greatly overestimates exposures but has not been acknowledged as a conservative overestimate by the environmental community or much of the public. By implementing animat dive behavior and movement, a more realistic assessment of impact can be obtained. Such assessments will have benefit to both the management of animal stocks and in providing relief from legal issues grounded on the misinterpretation of prior modeling assumptions and outcomes.

PUBLICATIONS

Houser, D. S. 2006. A method for modeling marine mammal movement and behavior for environmental impact assessment. IEEE Journal of Oceanic Engineering. 31(1):76-81. [published, refereed]

HONORS/AWARDS/PRIZES

Dorian S. Houser, BIOMIMETICA, R. Bruce Lindsay Award, Acoustical Society of America

Dorian S. Houser, BIOMIMETICA, Outstanding Young Alumni Award, Coker College